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MINIMIZATION OF POWER LOSSES USING GENETIC ALGORITHM

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ABSTRACT

In this paper the objective is to minimize the total power loss in the distribution system by determining the optimal position of the capacitor using Genetic Algorithm as an optimization technique. Therefore, on injecting capacitor at its best location, total real power and reactive power losses are minimized to an extent and as a result, power factor along with voltage profile are improved. In this project, proposed algorithm is tested on 24 bus power system, where Genetic Algorithm is used to compute the voltage and angle injecting values for placing shunt mode of capacitor at its best location resulting in minimization of total power losses are presented using ETAP Power Station 4.0 and Mat Lab R2008b. Further, improvement in power factor and voltage profile and also, minimization of total power losses in the distribution system before and after injecting capacitor at its best location are compared.

KEYWORDS: Shunt Capacitor; Reactive Power Compensator; Genetic Algorithm; Power Factor; Voltage Profile.

INTRODUCTION:
Reactive power compensation is a common technique, which is used for reducing the losses in the distribution system [1]. This can be done by the following methods such as Shunt Compensation, Synchronous Condensers etc. [2]. From the above, Shunt compensation is widely used [3]. The Shunt compensator used here is Capacitor. Installing shunt capacitors is more beneficial as it reduces kVA loading in generator, upgrades regulation of voltage and reduction of losses in the system [4]. Reactive power compensation is essential to avoid voltage collapse and improving the voltage profile [5].

In this work optimal positioning of capacitors are determined using Genetic algorithm. This algorithm is useful for reducing losses, improving power factor and upgrading voltage profile in the system [6]. Installation of capacitors evaluates the position of the same to be placed which reduces the losses and increases the voltage profile in the system.

A. Reactive Power Compensation:
The compensation technique used here is Shunt Compensation. Shunt connected capacitors maintain the voltage levels by compensating the reactive power to transmission line. This has been widely used in distribution system to regulate the voltage magnitude, improve the voltage quality, increase transmitted power, and enhance system stability and voltage stability.

B. Objective of the work:
Objectives of this proposed project are as follows:

- To improve power factor i.e., unity (0.8 to 1.0) and voltage profile, so as to increase the power system efficiency.
- To minimize power losses in the distribution system and improvement of voltage profile.

GENETIC ALGORITHM:
Genetic Algorithms (Gas), adaptive heuristic search algorithm, powerful, successful problem-solving strategy, based on the evolutionary ideas of natural selection and genetics, especially principles by Charles Darwin of "Survival of the Fittest".

C. Parameters of Genetic Algorithm:
The parameters of Genetic Algorithm are:

- Population size and number of chromosomes.
- Selection rate.
- Crossover probability.
- Mutation probability.
- Maximum number of generations.

D. Computing Voltage and Angle injecting values using Genetic Algorithm:
In this project, GA is used to compute the voltage and angle injecting values. GA, a global search technique, with five stages are used to find the best fitness (capacitance) value for injecting the Shunt Capacitor, without any prior knowledge or special properties of the objective function and thus produce high quality solutions. The major steps of this algorithm are:

Step1: Generation of Initial Chromosome

Step2: Fitness Function

Step3: Crossover operation

Step4: Mutation Operation

Step5: Termination

The flowchart of Genetic Algorithm for placement of Capacitor is give below:

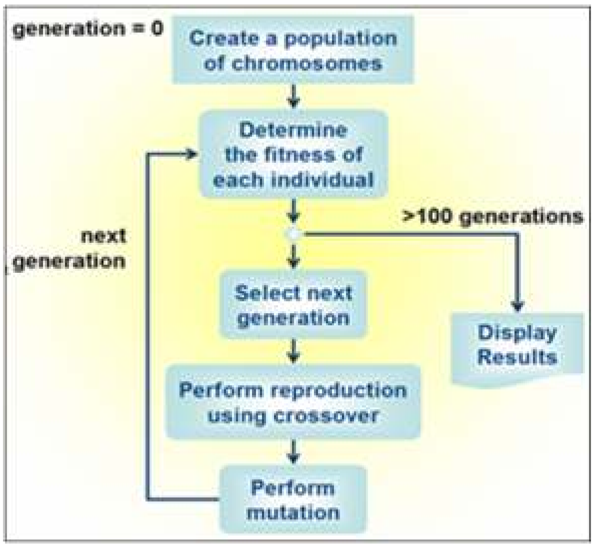

Fig. 1: Flowchart of OCP using Genetic Algorithm

E. Benefits of Genetic Algorithm:
The benefits of Genetic Algorithm are:

- Supports multi-objective optimization.
- Flexible building blocks for hybrid applications.
- Always an answer; answer gets better with time.
- Easy to exploit previous or alternate solutions.

RESULTS AND DISCUSSION:
F. Without Placement of Capacitor:
The proposed method has been implemented on a 24 bus system and the results so obtained are found to be satisfactory. The objective function is the minimization of the total real and reactive power losses in the distribution system. Different operating conditions are considered for finding the optimal choice and location of Capacitors.

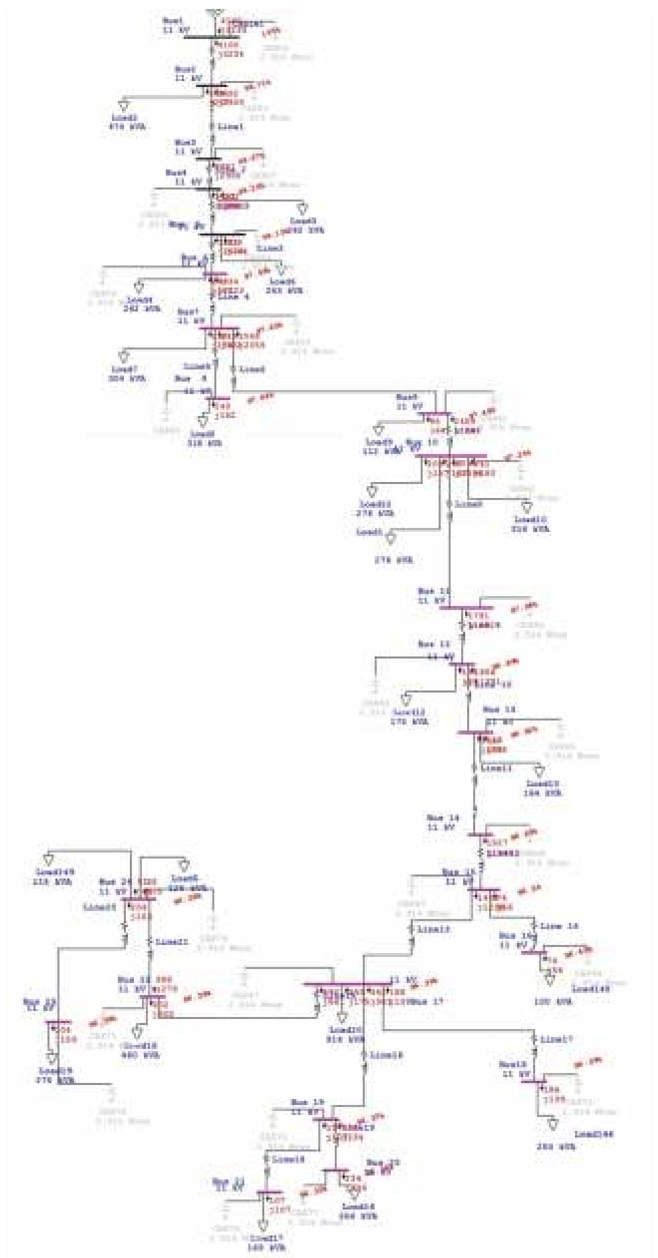

Fig. 2: Single line diagram for 24 bus system without capacitor

G. Power Losses before Capacitor Placement:

Table I. Power Losses before Capacitor Placement

BUS NO:	KW	KVAR
1	0.1	0.1
2	1.3	1.3
3	16.4	11.8
4	3.6	2.6
5	5.3	3.8
6	11.1	8.0
7	0.0	0.0
8	4.7	3.3
9	6.2	4.5
10	3.4	2.4
11	3.4	2.4
12	46.1	45.1
13	4.6	3.2
14	0.8	0.9
15	1.6	1.1
16	0.0	0.0
17	0.1	0.0
18	0.1	0.0
19	0.0	0.0
20	0.0	0.1
21	0.0	0.0
22	0.0	0.0
23	0.0	0.0
24	0.0	0.0
Total Power Losses	112.0	93.9

Power Losses in 24 bus system without placement of capacitor:
Real Power losses = 112.0 kW
Reactive Power losses = 93.9 kVAR

Table II. Power Factor before Capacitor Placement

BUS NO:	VOLTAGE PROFILE
1	0.9512
2	0.9871
3	0.9867
4	0.9825
5	0.9815
6	0.9799
7	0.9765
8	0.9764
9	0.9768
10	0.9724
11	0.9706
12	0.9635
13	0.9682
14	0.9655
15	0.9650
16	0.9649
17	0.9639
18	0.9637
19	0.9636
20	0.9638
21	0.9639
22	0.9639
23	0.9638
24	0.9638
Total Voltage Profile	0.9635

Table III. Voltage Profile before Capacitor Placement

BUS NO:	POWER FACTOR
1	0.785
2	0.786
3	0.785
4	0.785
5	0.784
6	0.783
7	0.781
8	0.800
9	0.778
10	0.777
11	0.768
12	0.707
13	0.763
14	0.763
15	0.800
16	0.761
17	0.800
18	0.709
19	0.708
20	0.709
21	0.800
22	0.800
23	0.785
24	0.785
Total Power Factor	0.707

H. Capacitor value obtained by Genetic algorithm:

GA report is generated with a waveform – best fitness versus best generation. Values are obtained by using Mat-Lab R2008b are injected and the power losses reduction observed.

Maximum Generation = 100
Best Fit = 800
Best Generation = 98
Amount of Capacitor Value injected in kVAR = 2.1584 kVAR
Optimal Location of Capacitor = Bus 12

This best fitness value obtained through Genetic Algorithm is injected in each and every bus in the 24 bus power system, to determine the best location to inject the Shunt Capacitor, using ETAP software and the output received shows that the losses at Bus 12 are comparatively reduced than the losses at other buses and the power factor and voltage profile has also shown improvement at bus 12 than other buses.

Table IV. Optimal Sixe of Capacitor to be Installed in 24 Bus System

NODE	SIZE OF CAPACITOR (KVAR)
12	2.1584

I. With placement of capacitor

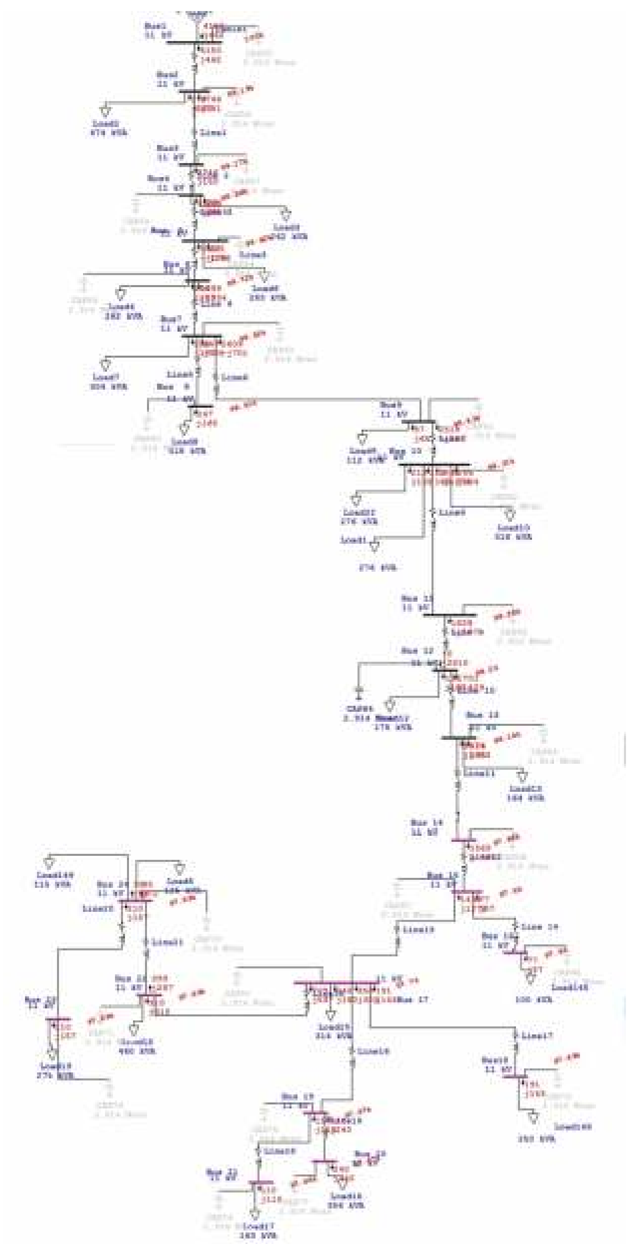

Fig. 3: Single line diagram of 24 bus system with Capacitor

Table V. Power Losses after Capacitor Placement

BUS NO:	KW	KVAR
1	30.8	30.8
2	0.8	0.6
3	10.4	7.4
4	2.3	1.6
5	3.3	2.4
6	7.1	5.0
7	0.0	0.0
8	3.1	2.2
9	4.2	3.0
10	3.1	2.2
11	3.1	2.2
12	11.1	11.1
13	4.7	3.3
14	0.8	0.9
15	1.7	1.2
16	0.0	0.0
17	0.1	0.0
18	0.1	0.0
19	0.0	-0.1
20	0.0	0.0
21	0.0	0.0
22	0.0	0.0
23	30.8	30.8
24	0.8	0.6
Total Power Losses	76.8 kW	63.6 Kvar

Power Losses in 24 bus system with placement of capacitor:
Real Power losses = 76.8 kW
Reactive Power losses = 63.6 kVAR

Table VI. Power Factor after Capacitor Placement

BUS NO:	POWER FACTOR
1	0.994
2	0.995
3	0.998
4	0.998
5	0.998
6	0.998
7	0.994
8	0.800
9	0.965
10	0.956
11	0.821
12	0.999
13	0.966
14	0.963
15	0.963
16	0.961
17	0.800
18	0.907
19	0.907
20	0.907
21	0.800
22	0.800
23	0.800
24	0.800
Total Power Factor	0.999

Table VII. Voltage Profile after Capacitor Placement

BUS NO:	VOLTAGE PROFILE
1	0.9919
2	0.9919
3	0.9917
4	0.9888
5	0.9882
6	0.9872
7	0.9852
8	0.9851
9	0.9843
10	0.9831
11	0.9826
12	0.9920

BUS NO:	VOLTAGE PROFILE
13	0.9814
14	0.9786
15	0.9780
16	0.9780
17	0.9770
18	0.9769
19	0.9767
20	0.9767
21	0.9766
22	0.9769
23	0.9769
24	0.9769
Total Voltage Profile	0.9920

J. Graphical Representation of Power Losses in 24 Bus System:

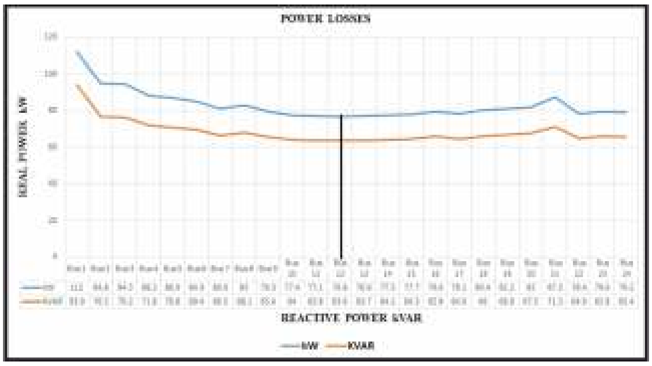

Fig. 4: Graphical Represenation of Power losses in 24 bus system

K. Comparison Report:

Improvement in Power Factor and Voltage Profile With and Without Shunt Capacitor:

After injecting the Shunt Capacitor at its best position, Bus 12, the Power Factor has increased from 0.785 to 0.999 and Voltage Profile has improved from 0.9635 to 0.9920. Thus, the system efficiency is improved. Thus, the results obtained after injecting Shunt Capacitor are tabulated and compared with the results obtained before injecting Shunt Capacitor.

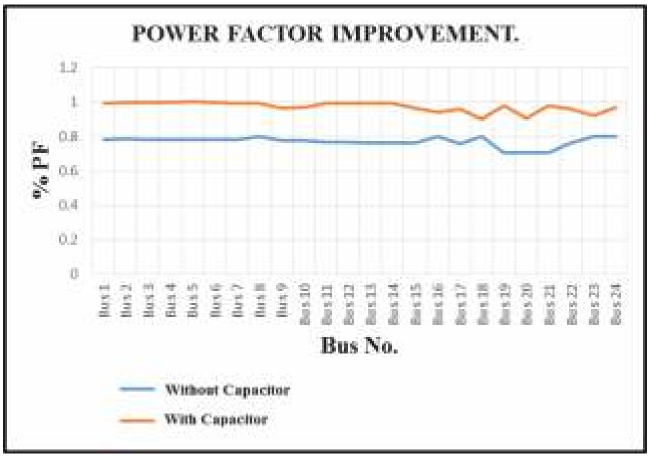

Fig. 5: Improvement in Power Factor With and Without Shunt Capacitor.

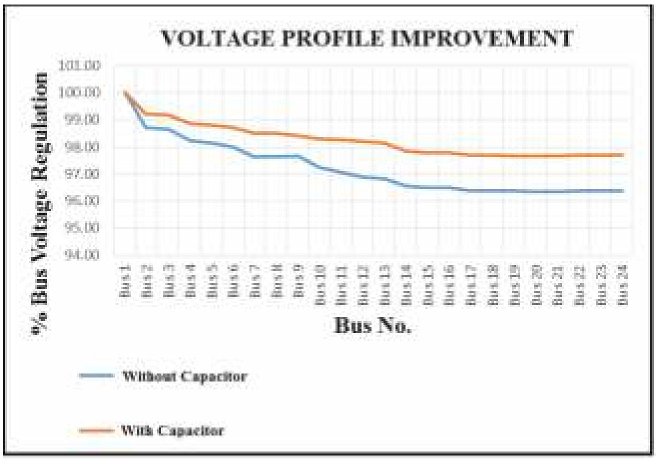

Fig. 6: Voltage Profile Improvement With and Without Shunt Capacitor

Minimization of Power Losses in Distribution System with and without Shunt Capacitor:

Finally, after placing the best fitness value at the best place, Bus 12, the reduction in total power losses in the distribution system is observed and compared with the reduction in total power losses in distribution system before and after placing best fitness value.

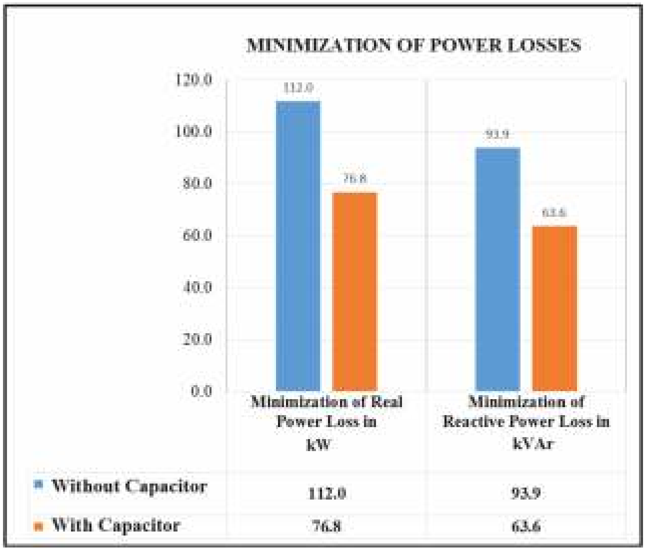

Fig. 7: Minimization of Power Losses Using Genetic Algorithm Bar Chart

Therefore, graphical representations shown in Figure 5, 6 and 7, determines that by injecting Shunt Capacitor at its optimal position, the Power Factor and Voltage Profile are improved and increases system efficiency along with power losses in distribution system of the system minimized.

CONCLUSION:

Genetic Algorithm based approach is proposed to determine the best location of Shunt Capacitors at different loading condition in power system. Further, on injecting the Shunt Capacitors at the determined optimal position in the power system, the total power losses in the distribution system of the system are minimized, and power factor along with voltage profile are improved and also, system efficiency is increased. Therefore, the proposed Genetic Algorithm is an effective and a practical method for the allocation of Shunt Capacitors.

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